Hadronic Decays of $J/\psi(1^3S_1)$ and $\psi'(2^3S_1)$ Through Vitrual Photons

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Abstract

The latest data for J/ψ and ψ' leptonic decays, and the latest measurement of the R–parameter are used to show that the present summary values of the branching ratios of the virtual photon mediated hadronic decays of both J/ψ and ψ' are overestimated. The current best results are $B(J/\psi \to \gamma^* \to h) = (13.3 \pm 0.3)\%$, and $B(\psi' \to \gamma^* \to h) = (1.65 \pm 0.10)\%$.

The $J/\psi(3097)$ and $\psi'(3686)$ 1^{--} states of charmonium couple to leptons only through virtual photons, and the branching ratios $B(J/\psi, \psi' \to \gamma^* \to hadrons)$ are among the largest decay ratios for both. These ratios were first reported by Boyarski *et al.* [1] and Luth *et al.* [2] from the 1975 measurements with the Mark I detector at SLAC. The Review of Particle Properties (PDG) has continued to quote these results ever since [3]. The quoted values are:

$$B(J/\psi \to \gamma^* \to h) = (17.0 \pm 2.0)\%\,, \tag{1}$$

$$B(\psi' \to \gamma^* \to h) = (2.9 \pm 0.4)\%\,. \tag{2}$$

Both these results were obtained by using the relation

$$\begin{aligned} B(J/\psi, \psi' \to \gamma^* \to h) &= \frac{\sigma_h(nonresonant)}{\sigma_l(nonresonant)} \times B_l(J/\psi, \psi' \to l^+l^-) \\ &\equiv R(nonresonant) \times B(J/\psi, \psi' \to l^+l^-)\,. \end{aligned} \tag{3}$$

Boyarski *et al.* [1] reported $B(J/\psi \to \mu^+\mu^-) = (6.9 \pm 0.9)\%$. Using the value $R = 2.5 \pm 0.3$ measured by Augustin *et al.* [4], they obtained $\Gamma(J/\psi \to \gamma^* \to h) = (12 \pm 2)$ keV, or equivalently the PDG result of Eq. (1).

More recently, much more precise result for both $R(nonresonant)$ and the leptonic branching ratio have become available. BES [5] has reported high precision results for R in the region 2–5 GeV, and PDG [3] itself has fitted and summarized the latest results for the leptonic branching ratios. The R values measured by BES [5] are constant in the region 2.0 to 3.73 GeV (Fig. 1). The result of our fit to these data is

$$R = 2.26 \pm 0.04 \tag{4}$$

which is very close to the theoretical expectations for three flavors, R=2.13 (correct to third order) [3]. The average of $B(J/\psi \to e^+e^-)$ and $B(J/\psi \to \mu^+\mu^-)$ is [3]

$$B(J/\psi \to l^+l^-) = (5.90 \pm 0.09)\%\,. \tag{5}$$

These leads to

$$B(J/\psi \to \gamma^* \to h) = (13.3 \pm 0.3)\%\,, \tag{6}$$

a result which represents a large improvement over Eq. (1).

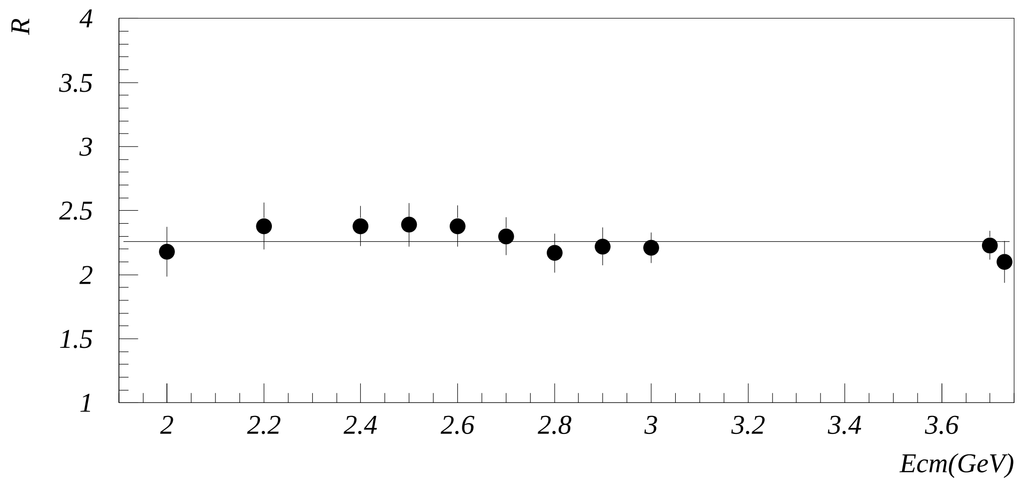

Figure 1: R measurements in the c.m. energy range from 2.0 to 3.73 GeV from BES [5] with best fit, R=2.26±0.04.

For $\psi'(2^3S_1)$ Luth *et al.* [2] reported $B(\psi' \to e^+e^-) = (0.93 \pm 0.16)\%$ and apparently used R=3.1 to obtain $B(\psi' \to \gamma^* \to h) = (2.9 \pm 0.4)\%$. The PDG listing is $B(\psi' \to l^+l^-) = (0.73 \pm 0.04)\%$ [3]. Using fitted value of R in Eq. (4), we obtain

$$B(\psi' \to \gamma^* \to h) = (1.65 \pm 0.10)\%\,, \tag{7}$$

a result which is significantly different from that of Eq. (2).

Since hadronic decays through virtual photons are included in the total hadronic decays, these revised values do not change the branching ratios, $B(J/\psi, \psi' \to h)$, but they do alter the estimates of $B(J/\psi, \psi' \to ggg)$.

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References

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